



# **HOMER as a Marine Corps Pre-Deployment Tool To Evaluate Power Solutions**

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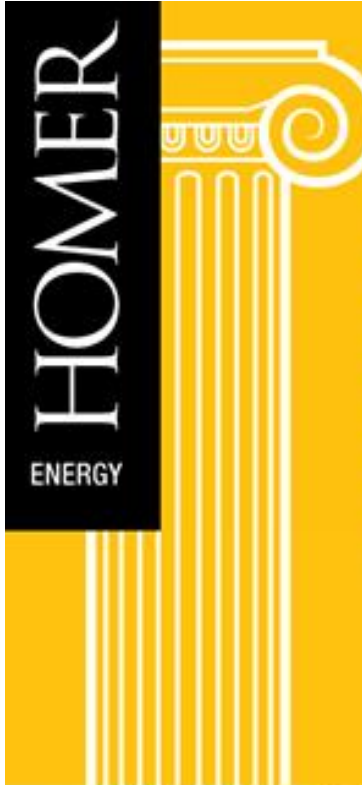
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- NPS - June '08
- NREL Internship – Summer '09
- Afghanistan MEAT – Sept '09
- Expeditionary Energy Office – Oct '10

## Expeditionary Energy Office (*E<sup>2</sup>O*)

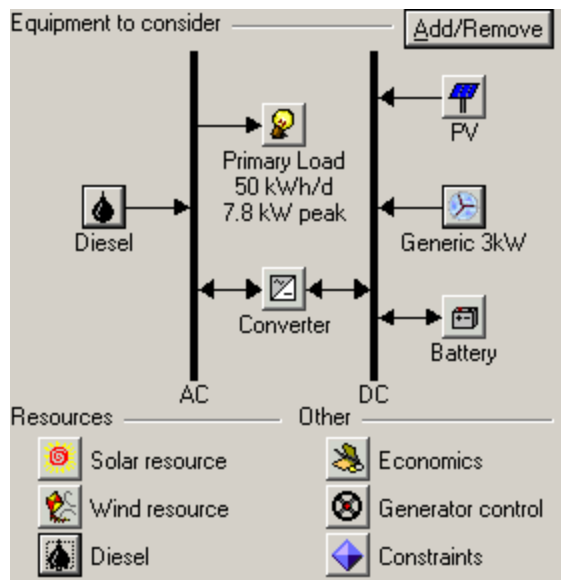
- Commandant's Vision: "Be the premier, self-sufficient expeditionary force, instilled with an ethos, that efficient use of vital resources equate to increased combat effectiveness."
- Reduce Fuel/Water Moved Around the Battlefield
- ExFOB



- Micropower Optimization Tool
  - Developed at NREL
    - Now privately owned
  - Simulation of micropower systems
  - Optimization driven by cost analysis



## Schematic Diagram



## Solution Space

**Optimization Inputs**

This table displays the values of each optimization variable. HOMER builds the search space, or set of all possible system configurations, from this table and then simulates the configurations and sorts them by net present cost. You can add and remove values in this table or in the Sizes to Consider table in the appropriate input window.

Hold the pointer over an element name or click Help for more information.

	PV Array (kW)	G1	G3	Dsl (kW)	Batteries	Converter (kW)
1	0.000	0	0	0.00	0	0.00
2	1.000	1	1	8.00	4	2.00
3	2.000	2	2		8	4.00
4	4.000	3	3		12	8.00
5	8.000		4		24	
6	12.000				48	
7	16.000				96	
8					128	
9						
10						

Average primary load: 50 kWh/d  
Peak primary load: 7.79 kW

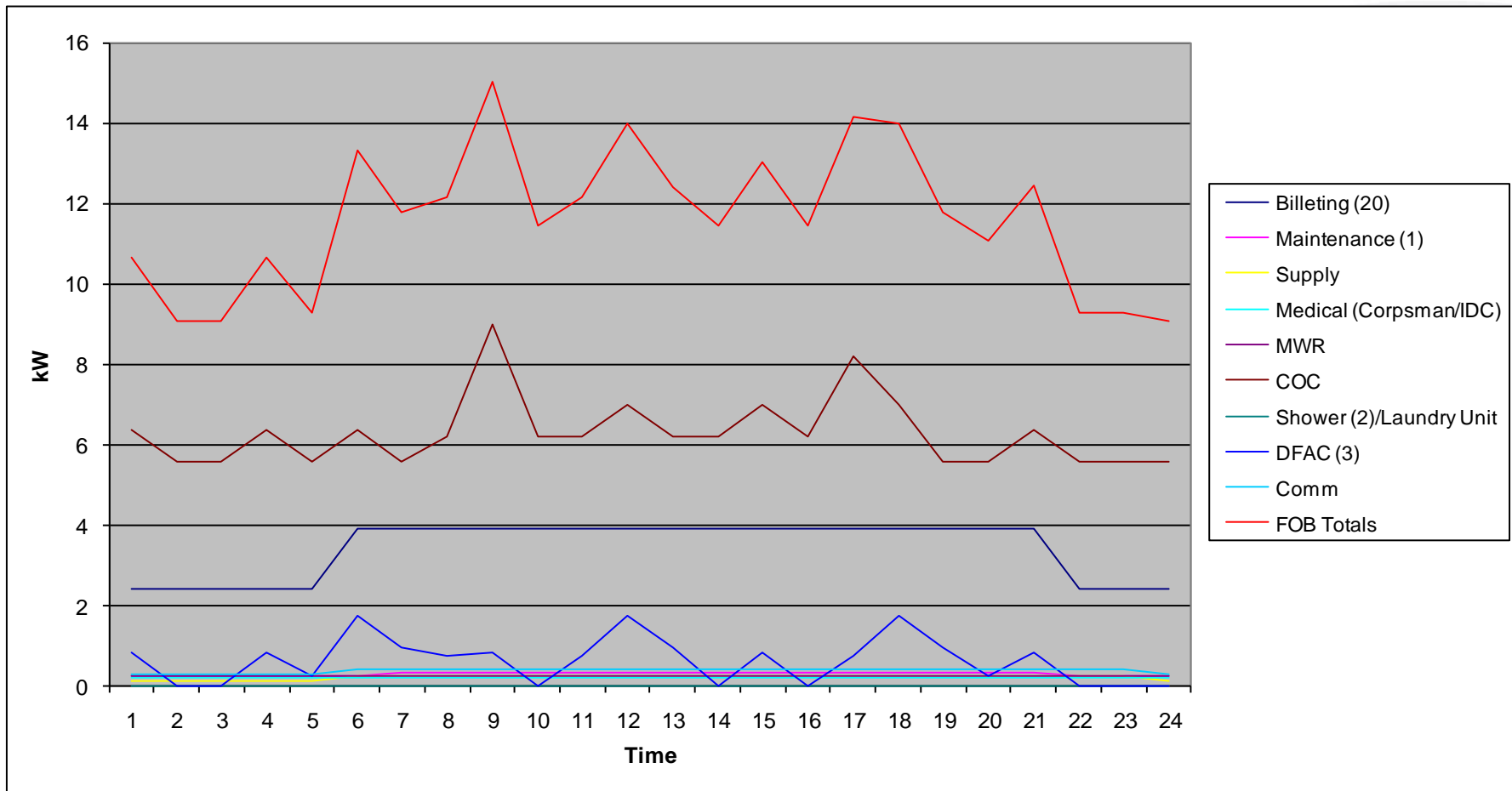
Help Cancel OK

- Thesis Question: Can HOMER be utilized as a pre-deployment tool to meet the Marine Corps' need to evaluate power solutions for unique locations?
- Answer: YES, If it is CALIBRATED





## Company Power Profile Austere







## Two Experiments – on campus

### Objectives:

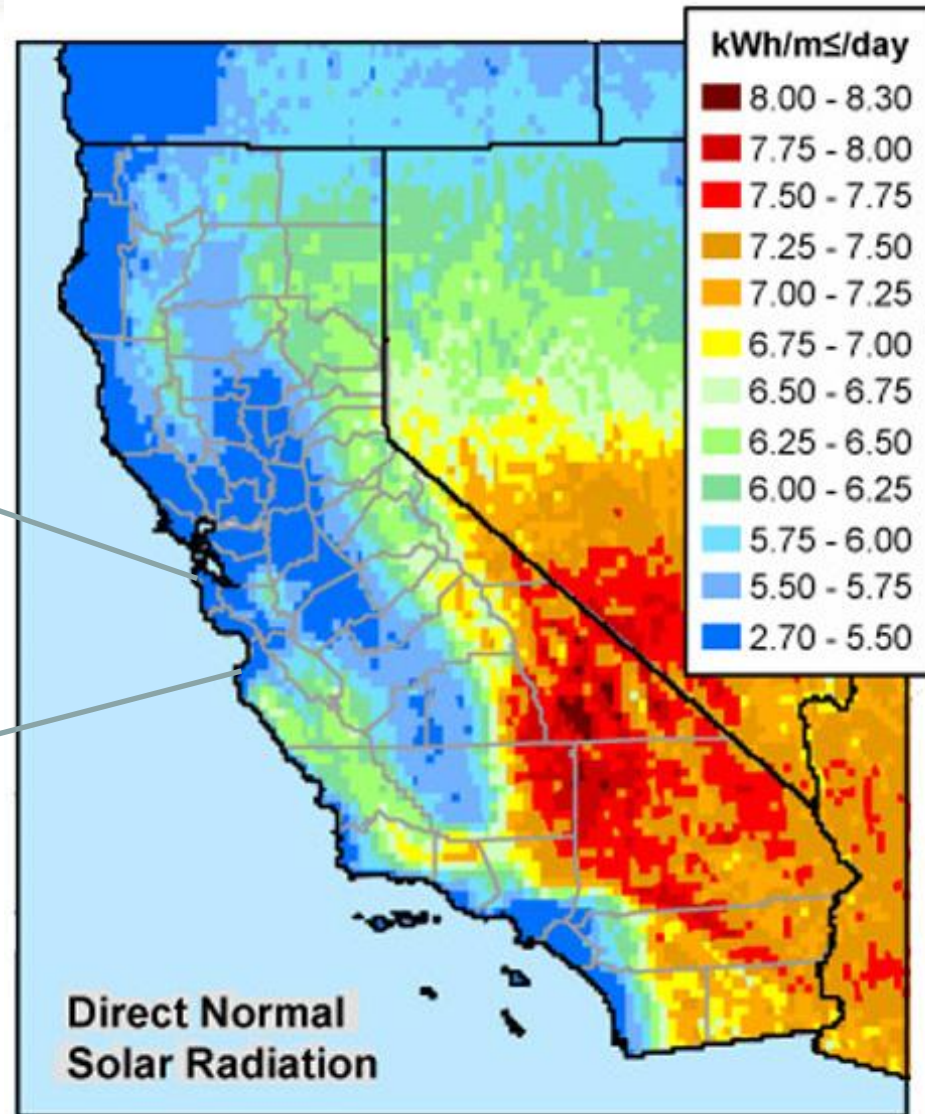
- Measure power production over one month and compare HOMER's modeled production.
- Calibrate HOMER's variables to the particular system.



# Controlled Experiments

San  
Francisco

Monterey



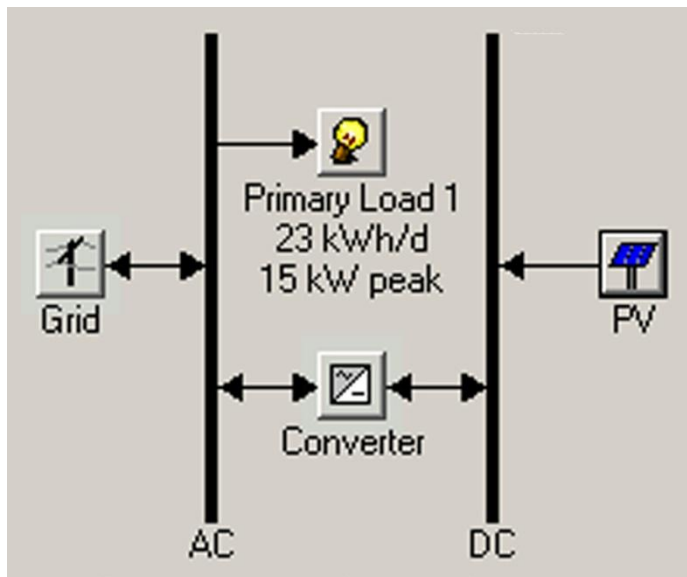
- Grid-tied-PV system
  - 11.48kW PV
  - Pacific Gas & Electric
- Wind-PV system
  - 60 W PV panel (Powerfilm)
  - 50 W PV panel (Kyocera)
  - 400 W wind turbine (AirX)





- Period – Apr 2 – May 1, 2010
- Equipment – (56) Kyocera 205W panels
  - (3) SunnyBoy SB3800U Inverters
    - Assembled in 2006.
- System Rated Power – 11.48kW
- Measured Energy:
  - 1270 kWh for the month

## Critical Variables



Azimuth	231 degrees
Slope	15 degrees
Temp Effects	Ignored
Economics	Ignored
Solar Resource	NASA (monthly avg)
Converter Eff.	94.5%
Derating Factor	80%

	PV Usable Energy (kWh)	Accuracy
Measured Data	1270	
HOMER Model	1612	+27%

- Possible Sources of Inaccuracy:
  - Temperature Effects
  - Solar Irradiance Estimates
  - Performance of System

## Kyocera KD205GX Data Sheet

### Homer Inputs:

☒ Consider effect of temperature

Temperature coeff. of power (%/°C)

-0.92

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Nominal operating cell temp. (°C)

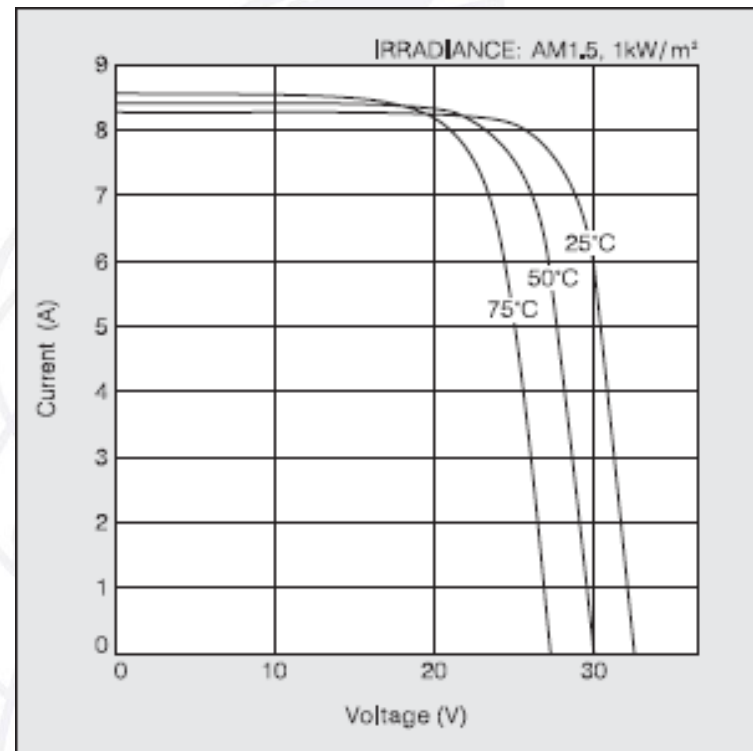
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Efficiency at std. test conditions (%)

16

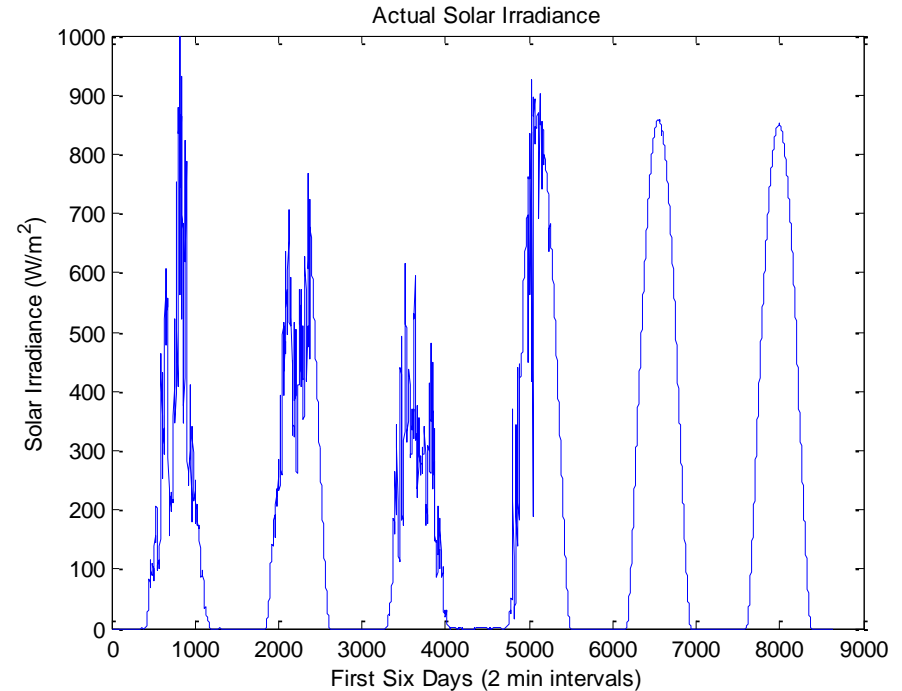
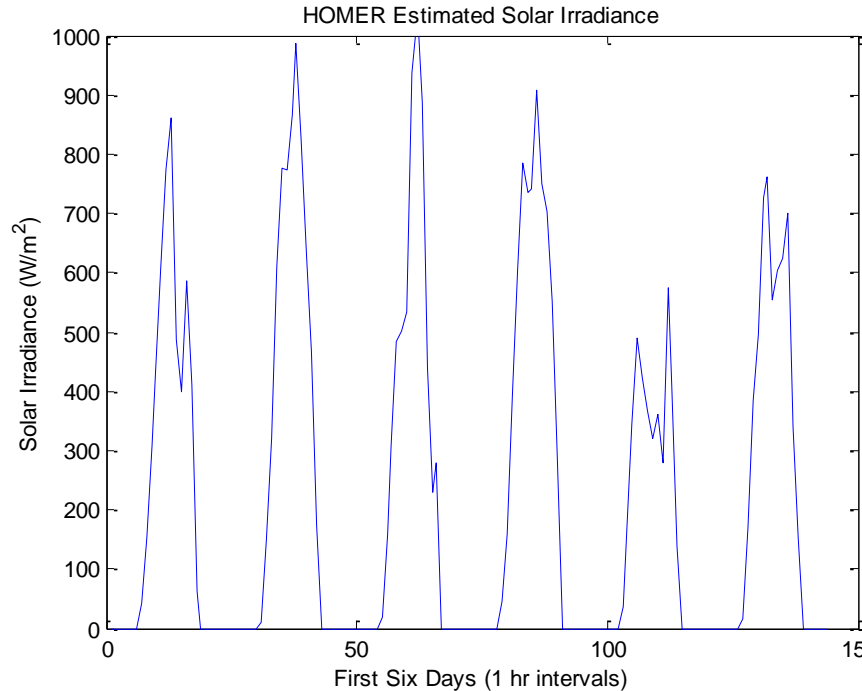
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	PV Usable Energy (kWh)	Accuracy
Measured Data	1270	
HOMER Model	1612	+27%
Add Temp Effects	1539	+21%



Compare HOMER's Estimated Irradiance to Actual Irradiance:

HOMER is 9% Higher.

	PV Usable Energy (kWh)	Accuracy
Measured Data	1270	
HOMER Model	1612	+27%
Add Temp Effects	1539	+21%
Add True Solar Irradiance	1483	+17%

## Derating Factor (DF) in HOMER

- Accounts for:
  - Dust on the panels
  - Wiring losses
  - Deviation from optimal power point
- Default: 80%

## Precise Calibration – Vary DF

- Outcome: 68.5%

	PV Usable Energy (kWh)	Accuracy
Measured Data	1270	
HOMER Model	1612	+27%
Add Temp Effects	1539	+21%
Add True Solar Irradiance	1483	+17%
Vary Derating Factor	1270	--



## Experimental Forward Operating Base (ExFOB)

“Simulate forward deployed force energy and water demands and to test and evaluate alternative solutions to meet their needs.”

- Demand Reduction
- **Alternative Power**



## Selected Power Equipment

### PowerShade Solar Field Shelter



### ZeroBase Energy Regenerator



### GREENS Solar Power System



### NEST Solar Light Trailer



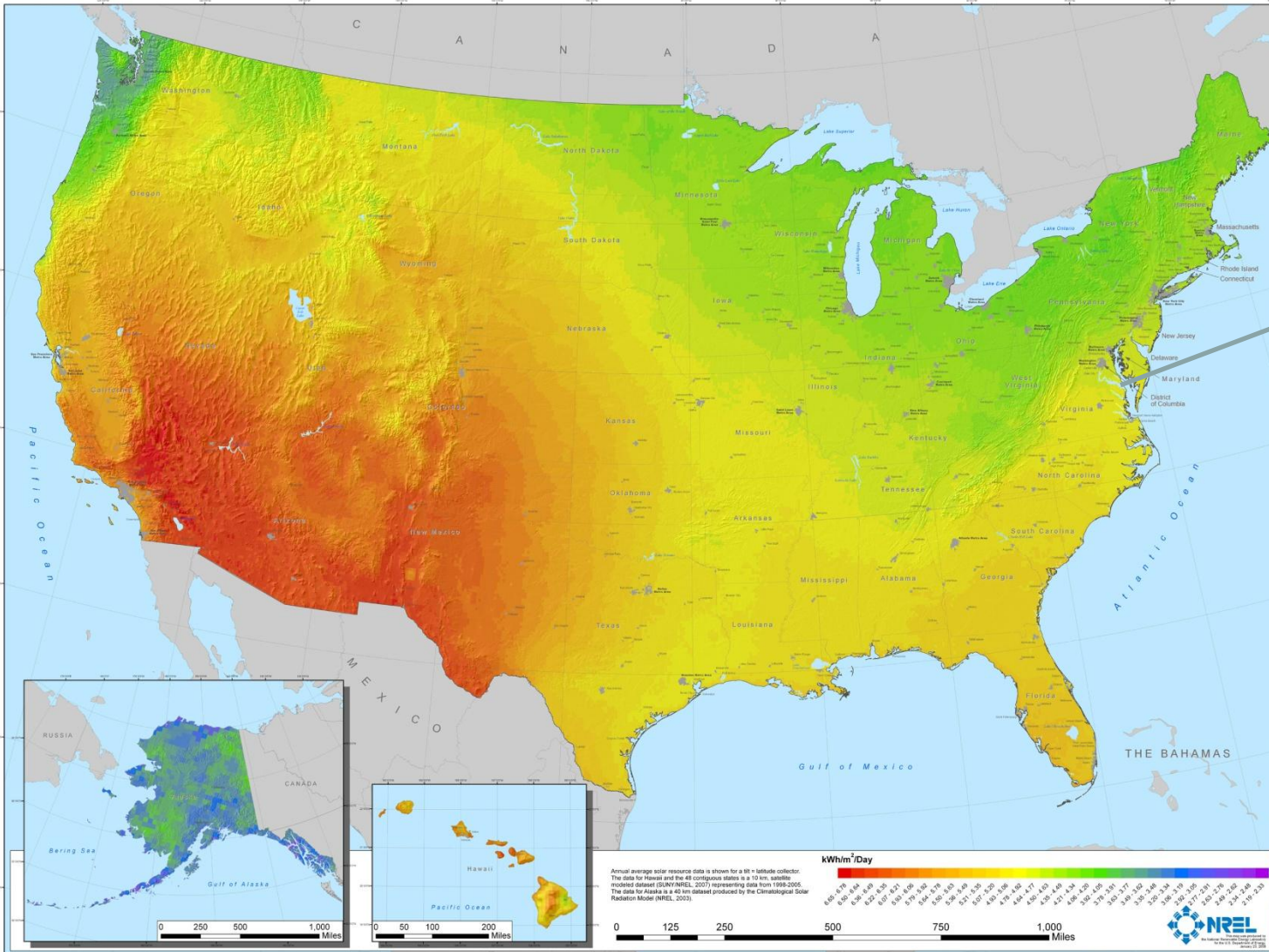




## COMPANY EQUIPMENT

	Rated Pwr	No. of Panels	Pwr/System	No. of Systems	Pwr/Company
<b>PowerShade</b>	1 kW	1	1 kW	2	2 kW
<b>GREENS</b>	200 W	8	1.6 kW	3	4.8 kW
<b>ZeroBase</b>	240 W	5	1.2 kW	3	3.6 kW
<b>NEST</b>	175 W	4	.7 kW	10	7 kW
Total					<b>17.4 kW</b>

## United States Photovoltaic Solar Resource : Flat Plate Tilted at Latitude



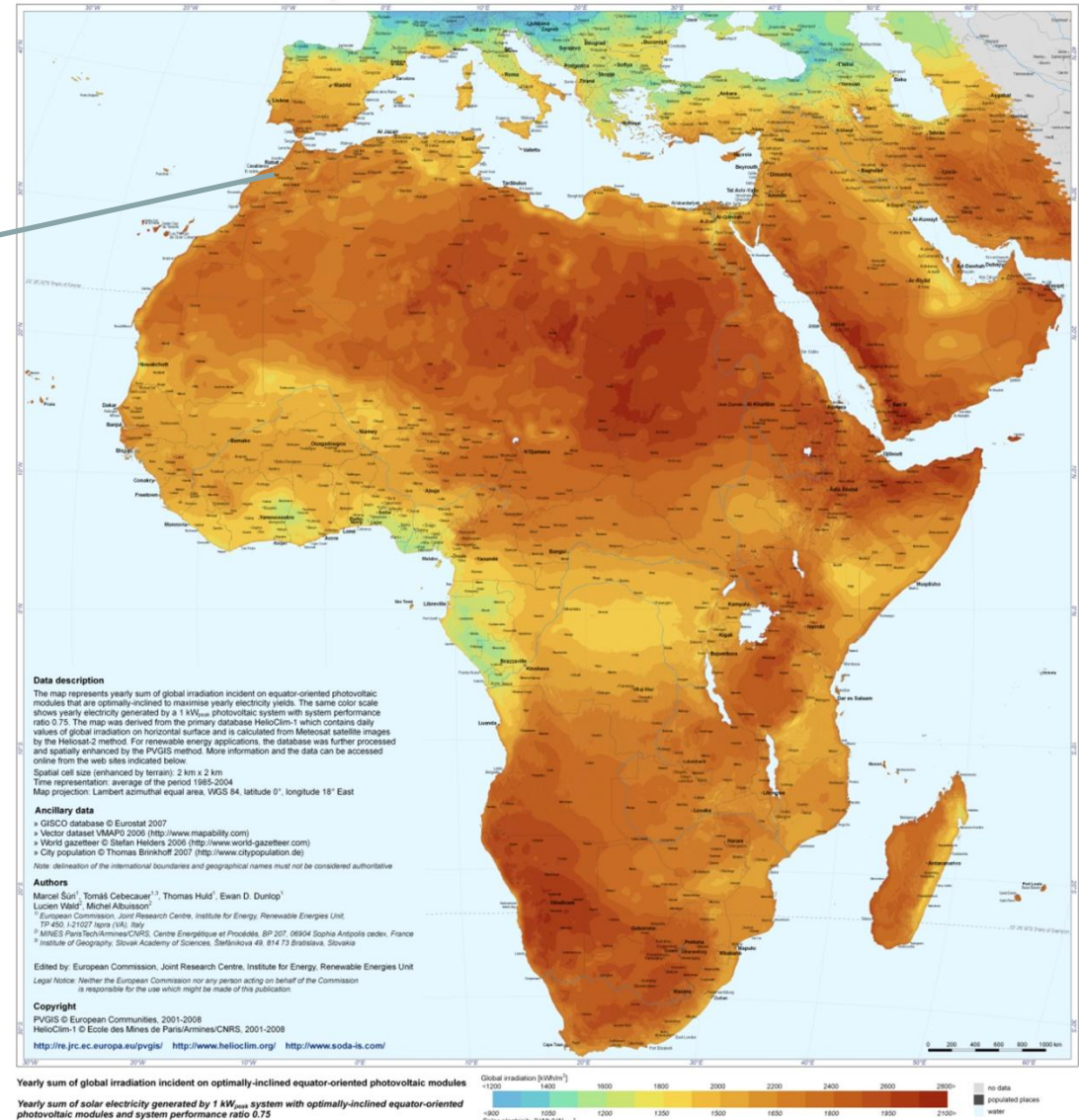
Selection:  
March

Quantico,  
Virginia

## Demonstration: May

Morocco

### Photovoltaic Solar Electricity Potential in the Mediterranean Basin, Africa, and Southwest Asia

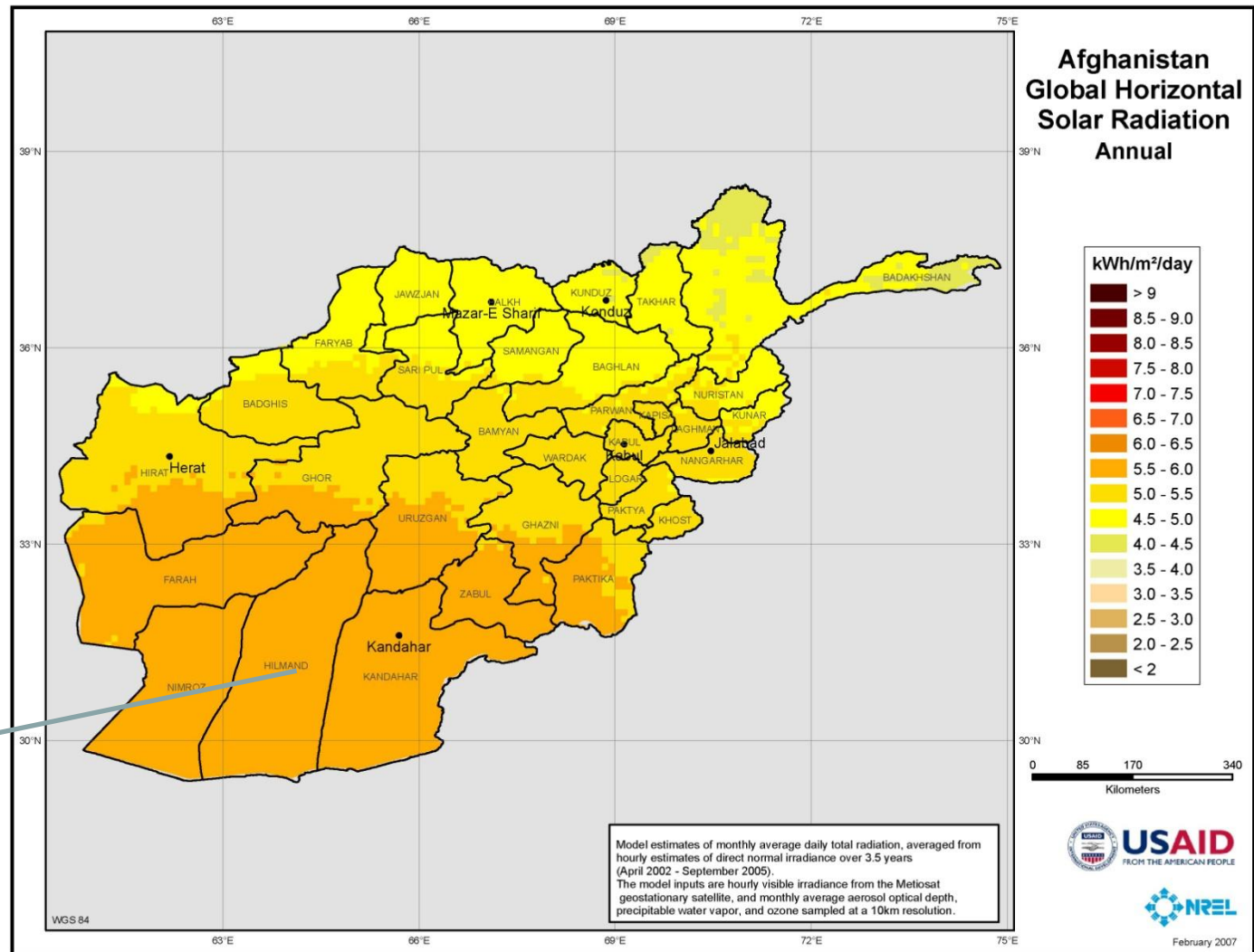


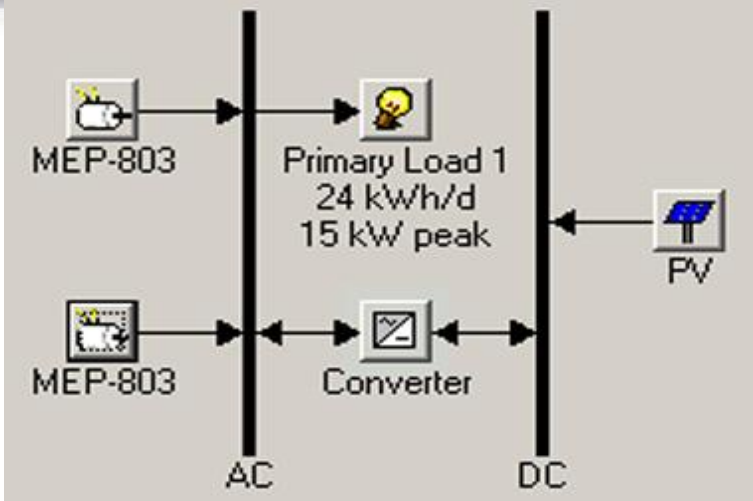




## Deployment: October

Helmand  
Province





## Combine All 4 Systems

- Slope 0°
- No Temp Effects
- Inverter Efficiency (90%)

= LOW BOUND

## ExFOB Results

	Quantico (kWh)	Morocco (kWh)	Afghanistan (kWh)
<u>PV Combined</u>	<b>1645</b>	<b>2074</b>	<b>1984</b>
Percent of Load	19%	24%	23%

## Model Each PV System Separately:

	Slope	Temp Effects	Inverter Efficiency
Solar Shade	0°	N	Default
GREENS	30°	Y	92%
ZeroBase	45°	N	Default
NEST	55°	N	Default



## ExFOB Results

	Quantico (kWh)	Morocco (kWh)	Afghanistan (kWh)
<u>PV Combined</u>	<b>1645</b>	<b>2074</b>	<b>1984</b>
Percent of Load	19%	24%	23%
<u>Individual</u>			
Solar Shade	191	223	240
GREENS	671	726	769
ZeroBase	430	449	501
NEST	822	839	940
	<b>2114</b>	<b>2272</b>	<b>2484</b>
Percent of Load	24%	26%	29%



## ExFOB Results

Why Does It Matter?  
23% vs 29% of the Monthly Ld?

# Fuel

### Afghanistan (kWh)

#### PV Combined

**1984**

Percent of Load

23%

#### Individual

Solar Shade

240

GREENS

769

ZeroBase

501

NEST

940

**2484**

Percent of Load

29%

Method	Fuel (L)
--------	----------

23%	3402
-----	------

23%	3402
-----	------

8.2% Increase in Fuel Demand

29%	3145
-----	------

29%	3145
-----	------

- Reduction in fuel demand = reduction in risk of IED
- Critical Information to Logisticians and Cost Estimators

- HOMER should be utilized as a pre-deployment tool
  - Calibration is the key
- Effective use of HOMER throughout the ExFOB process could have contributed to a more effective evaluation of equipment



# Questions?